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(71) Applicant (*for all designated States except US*): EMHART INC. [US/US]; Drummond Plaza Office Park, 1423 Kirkwood Highway, Newark, DE 19711 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): MIELKE, Karl-Heinz [DE/DE]; Quellstrasse 24, D-52249 Eschweiler (DE).

(74) Agents: MURPHY, Edward, D. et al.; The Black & Decker Corporation, 701 E. Joppa Road, Towson, MD 21286 (US).

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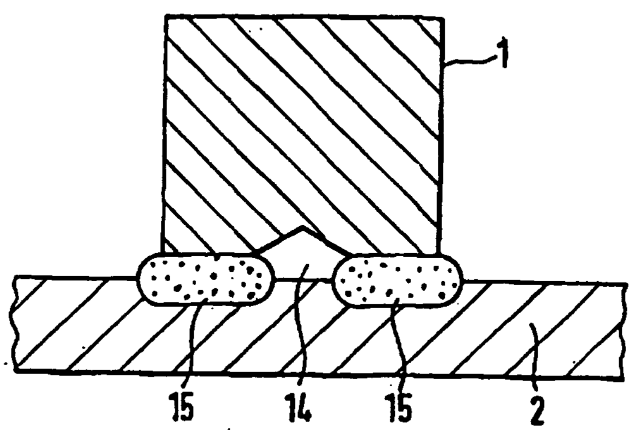
(54) Title: ARC WELDING METHOD AND STUD WITH TAPERED ANNULAR WELDING EDGE FOR USE WITH SAID METHOD

(57) Abstract

A method for welding a stud (1) with a structure (2), in which said stud (1) with an edge tapering downwards in its cross section is brought into contact with the structure (2), then loaded with an electric current, said stud being then withdrawn to form an arc and finally plunged into molten metal (15).



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ARC WELDING METHOD AND STUD WITH TAPERED ANNULAR WELDING EDGE FOR USE WITH SAID METHOD

Technical Field

The invention relates to a method for welding a stud to a structure and a stud for the carrying out the method.

Studs have a wide range of uses, in particular in the automotive industry. The studs are materially bonded with the metal body of a vehicle. The material fusion of a stud with the sheet metal of the vehicle body is carried out in particular by arc welding. The stud as such has several functions; for instance it may serve as a support for plastic clips as a fastening for feed lines, especially fuel or brake lines.

Background Art

Known studs have a head and a shank connected to the head. The head of a stud is welded to the sheet metal of a vehicle body. The welding operation takes place according to the known method of drawn-arc welding. In this method, the stud is brought into contact with the sheet metal, the welding current is then switched on and the stud is drawn off the sheet metal so that an arc is formed between the stud and the sheet metal. While the arc is burning, part of the stud head and part of the sheet metal melt. When a sufficient amount of molten metal has been generated, the stud is driven into the melting. The welding operation as such can be influenced by several parameters. The influence of the individual parameters has various effects on susceptibility to error when welding studs with the drawn-arc method. Reference is made in this context to the "Untersuchung zur

Verringerung der Fehleranfälligkeit beim Bolzenschweißen mit Hubtechnik" by W. Rehm et al. published in "Schweißen und Schneiden", No. 34 (1982), Issue 9.

For the purpose of arc initiation, the head geometry of the stud must be designed accordingly. In this context, studs having a head with a conical tip are known in the art. Studs with a substantially flat head/front end are further known, with an ignition tip formed in the center of the front end. Studs with a flat front end are further known in the art.

In the known method for the material fusion of a stud, the tip of the stud, which is centrally located, if possible, is brought into contact with the sheet metal and an arc is ignited. While the arc is burning, there is a risk of short circuits. While an arc is burning, the stud begins to melt from the front end. Molten metal collects substantially in the central area of the front end of the stud. As a result, a drop of liquid molten metal forms at the stud and may come into contact with the sheet metal. If contact of the drop of molten metal from the stud is made with the sheet metal, a short circuit occurs. A short circuit leads to an energy loss during the welding operation; i.e. there is no continuity of the energy input during the welding operation. These discontinuities lead to inhomogeneity in the molten metal, which manifests itself in inferior welding quality.

The most commonly used studs are solid metal studs. Due to the solid design of the stud, problems arise with the welding of the stud to a relatively thin sheet of metal, as high energy input is required due to the large thermal capacity of the stud, so that there is a risk of deformation or

even melt-through of the sheet metal before the fusion of stud and sheet metal is accomplished. The problem of welding a stud to a thin sheet of metal is known. As a solution to this problem, it has been suggested that the polarity be changed in arc welding, so that less strain is placed upon the sheet metal.

Disclosure of Invention

The problem to be solved by the invention starts from this prior art to further develop the known method of welding a stud to a structure such that the potential risk of short circuits is reduced. A further object of the invention is to provide a method enabling durable welds to be achieved between a stud and relatively thin structures. A further object of the invention is to provide a stud which is specially suited to the design of a permanent weld with a structure, particularly a sheet metal.

A stud, in the meaning of this written text, is not only an essentially solid fastening part, but an arbitrary shaped fastening part which is, like a solid stud, weldable to a structure, for example, any hollow-faced stud, especially a thin-walled hollow fastening part, and/or a fastening part comprising extensions, recesses and/or bores on the side.

The method of the invention for welding a stud to a structure is distinguished in that a stud with a rim which tapers in cross section is brought into contact with the structure. The tapered edge of the stud is preferably rounded or converges acutely, so that the contact between the stud and the structure when the two are brought together is in the form of a line. After the stud has made contact with the structure, a welding current is

applied and the stud is pulled back to form an arc. In this way, in contrast to the known prior art, in which a substantially spot-like ignition of the arc is achieved, the method of the invention causes an arc to form along the edge. The arc thus formed is extended in an annular form. Surprisingly, it has been discovered that this kind of process control is less sensitive to shorting. The weld result as such is also improved because the formation of molten metal on the stud is more even. Furthermore, an even annular weld results in the form of a collar formed from the outside inwards, which is, therefore, always durable and strong on the outside.

To carry out the method according to claim 1, a stud is suggested having a tapered (preferably acutely tapered) edge for contact with a structure. According to the invention, the said edge is formed circumferentially. This stud design also permits welding of the stud by means of the drawn-arc welding method on relatively thin metal sheets. This is achieved because the tapered cross-section of the edge reduces heat transmission into the sheet metal. The edge is preferably formed circumferentially. In the simplest case, the front end of the stud is shaped like a hollow cone. The term hollow-cone-shaped includes not only a hollow cone in the strict geometrical meaning of the word but also related shapes such as a concave front end or one shaped like a ball-socket. When the stud is shaped in this way, molten metal flows into the cavity, so that the appearance of the weld is improved, because by contrast with welds as known in the art, a less pronounced collar occurs on the edge of the stud.

According to another advantageous thought of the invention, it is suggested that the edge tapers downwards in the inside of the stud and is designed as

a substantially tubular jacket portion. When the stud is shaped in this way, molten metal forms quickly, as the tube-like jacket portion reduces heat conduction into the stud, resulting in an improved temperature in the jacket portion and, hence, of the liquefaction of the same. As an alternative to this design of the stud, it is suggested that the edge should be tapered downward on the outside of the stud and be designed as a substantially tubular jacket portion. When the stud is designed in this way, a circumferential weld collar forms and can be subjected to optical inspection.

The studs described above can also have an axial bore, especially which is running right through, for example a bore with a thread, ending before the tubular jacket portion. Such a stud prevents the surface of the bore being spoilt by any splashes of molten metal.

A further suggestion is a stud with an edge tapered downward from a hole worked in the center of the stud. This hole can act as a space for collecting molten metal.

A preferred embodiment is a stud in which the angle of inclination of the tapered portion, particularly an angle between a slanted surface of the edge and a surface of the cross-section running substantially perpendicular to the longitudinal extension of the stud, is dependent on the thickness of the jacket portion. This results in improved weld performance of the stud.

Particularly for welding a stud onto relatively thick structures, preferably sheet metals, the angle between a slanted surface of the edge and a cross-

sectional surface running substantially perpendicular to the longitudinal extension of the stud is up to about 45°.

The edge has preferably a slanted surface, in which the angle between said slanted surface and a surface of the cross-section is between 5° and 15°, preferably between 7° and 10°, particularly 9°. The said surface of the cross-section runs substantially perpendicular to the longitudinal extension of the stud.

According to a further embodiment of the stud, it is suggested that said stud should have a threaded bore designed substantially coaxially to the circumferential edge. To ensure that spatter does not get on to the thread during welding, it is suggested as a further embodiment of the stud that the latter have a cover protruding at least partially from the edge into the threaded bore. Preferably, the cover is made of a synthetic material.

To ensure that the stud is accurately positioned when automatically fed into a welding apparatus, it is suggested that said stud has a shape that allows it to be positioned only in a predetermined position in a tool.

Preferably, the design of the stud should be such that the latter is asymmetrical in shape. Especially, it is useful, when the outer contour of the stud is shaped, so that its correct position can be recognized. For example, the stud comprises comparatively sharp edges on the weldable end and clearly recognizable roundings on the opposite end .

Brief Description of Drawings

Further advantages and features of the method and the stud will be explained by means of the embodiments shown in the drawings. Specifically:

Fig. 1 shows a section through a solid stud in accord with this invention;

Fig. 2 shows a section through a stud with a tubular jacket portion;

Fig. 3 shows a section through a tube-shaped stud;

Fig. 4 shows a section through a stud with a curved tapered rim;

Figs. 5 and 6 shows an enlarged partial sections of two different edge portions;

Fig. 7 shows a sectional view of a stud welded to a structure such as a metal sheet;

Fig. 8 shows a further embodiment of a stud in accord with this invention;

Fig. 9 shows a stud having a cover; and

Fig. 10 shows a stud with a feed device

Best Mode for Carrying Out the Invention

Fig. 1 shows a first embodiment of a stud 1. The stud 1 is formed substantially as a cylindrical solid stud. It has an edge 3 tapered downwardly in cross section for the purpose of making contact with a structure. As Fig. 1 shows, the edge 3 of the stud tapers from the axis 4 toward the external surface 5 of the stud. The edge 3 runs round the circumference.

Fig. 2 shows a second embodiment of a stud 1A. The stud 1A has a substantially tubular jacket portion 6. The edge 3A of the jacket portion 6 tapers from the inside of the stud toward the outside. Above the tubular jacket portion 6, the stud 1A is designed with a threaded bore 11. The tubular jacket portion 6 forms a chamber 8 into which molten metal may enter during welding.

Fig. 3 shows a tubular stud 1B. The stud 1B has a tapered edge 3B. The edge 3B has a slanted surface 9. The slanted surface 9 of the edge 3B includes an angle α with the cross-section surface, the said angle being between 5° and 15°, preferably between 7° and 10°, particularly 9°.

In the above embodiments, the slanted surfaces of the tapered edges 3, 3A and 3B are flat and constant. Of course, the angle of the taper may be changed at intervals along the surface, creating a series of flats if desired.

A further variation of the stud of this invention is shown in Fig. 4. The representation of the stud 1C in Fig. 4 shows that the surface 9C of the edge 3C is curved. Its curvature has a radius R. The tapered edge 3C is formed in

the tubular jacket portion 6C. In the center of the stud 1C is a milled recess 16. The taper of the edge can also be made from the outside of the stud toward the inside. The slanted surface of the edge then forms part of the surface of the stud. The stud 1C has a bore 7 going right through extending substantially in the longitudinal direction of the stud 1C. The through-going bore 7 extends into the chamber 8C.

Figures 5 and 6 show different designs of an edge portion. In Fig. 5, the edge 3D tapers to an acute end. Thus, looked at in cross-section, the edge has a tip 12, so that the stud 1, when placed on a structure 2, has only line of contact with the said structure. The flow of electric current or the formation of a welding arc takes place through the tip 12 so that high current densities are achieved.

Fig. 6 shows a further embodiment of an edge 3E. Here also, the edge 3E is tapered, ending in a rounded end 13. The radius of curvature of the rounded end 13 can be adapted according to the required welding result. The rounded end 13 enables better contact to be achieved between the edge and a structure. In both embodiments according to Fig. 5 and Fig. 6, a quasi linear contact is achieved between the stud and a structure 2.

To exemplify the application of this invention, Figure 7 shows a fusion connection between a stud 1 and a structure 2. The stud 1 corresponds in design to that of Fig. 1 before welding, and reference is made to the description of Fig. 1 to avoid repetition.

In use, the stud 1 of Fig. 1 is placed in contact with the structure with the tapered edge 3 touching the surface. A welding current is then applied. After application of the welding current, the stud 1 is withdrawn to form an arc. While the arc is burning, both the edge 3 of the stud 1 and parts of the structure 2 melt. After a prescribed time, the stud 1 is plunged into the molten metal. The welding current is switched off before or during plunging. Then the weld cools down. As shown in Fig. 7, part of the circumferential edge 3 has melted. Part of the molten metal has entered the cavity 14. The weld is substantially annular. The stud 1 and the structure 2 have a common weld area 15 that has set. Of course, the other illustrated embodiments of this invention operate in similar fashion.

Figure 8 shows an alternative stud 1F. The stud 1F has a substantially tubular jacket portion 6F. The edge 3F of the jacket portion 6F tapers from the inside of the stud toward the outside. Above the tubular jacket portion 6F, the stud 1F is provided with a threaded bore 11. The jacket portion 6F partially limits a chamber 8F into which the molten metal created by welding may enter during welding operation. To avoid spatter on the thread of the threaded bore 11, a plug-like cover 17 is provided, protruding from the edge 3F into the threaded bore 11. In the embodiment shown in the drawing, the cover 17 has a head 18 contiguous with a front end 19. The cross-section of the head 18 is larger than the cross-section of the threaded bore 11.

Fig. 9 shows a further embodiment of a stud 1G. The stud 1G has a substantially tubular jacket portion 6G tapering from the inside of the stud outwards. Above the tubular jacket portion 6G, the stud 1G has a threaded

bore 11. The stud 1 according to Fig. 9 is substantially rotationally symmetrical about the longitudinal axis 20. As shown in Fig. 9, the end zone 21 facing the edge 3 is substantially curved. The stud 1G is asymmetrical in its outer contour in relation to a plane of the cross-section substantially perpendicular to the longitudinal axis 20. The asymmetrical design of the outer contour of the stud 1G makes the said stud fit only into a specific predetermined position only in a tool.

Figure 10 shows the arrangement of the stud 1G according to Fig. 9 in the context of a tool 22. The tool 22 has a channel 23 limited by the parts 24, 25 of the tool. The internal cross-section of the channel 23 is designed such that a stud 1 can only be introduced in a predetermined position into the channel 23. As shown in Fig. 10, the channel 23 has two walls 26, 27, which come into contact with the curved zone 21 of the stud 1G. The effect of the walls is that, if the stud 1G were in a position in which the edge zone 21 were adjacent to the tool part 24, the said stud would not fit into the channel 23 because the edge 3G would be suspended on the walls 26, 27.

In further accord with the present invention, solid studs which are partially hollowed out in the lower area, can also be arc welded reliably, even to thin structures, as a ring-shaped weld is achieved which is very durable, particularly in the area of its periphery. It is accordingly intended that the appended claims cover all variations which come within the full spirit and scope of this invention.

Claims

1. Method for welding a stud (1) to a structure (2), in which the stud (1) with an edge (3), the cross-section of which tapers downwards in the inside of the stud, is brought into contact with the structure (2), loaded with an electric current, then withdrawn to form an arc and finally plunged into the molten metal (15).

2. Stud for carrying out the method of Claim 1, characterized in that the stud (1) has an edge (3) with a tapered cross-section preferably running to an acute end, to be placed in contact with a structure (2), said edge (3) tapering downwards inside the stud.

3. Stud according to Claim 2, characterized in that the edge (3) is formed all round the circumference.

4. Stud according to Claim 2, characterized in that the edge (3) is designed as a substantially tubular jacket portion (6).

5. Stud according to Claim 2, characterized in that the edge (3) tapers downwards from a cavity (16) worked into the center of the stud.

6. Stud according to Claim 2, characterized in that an angle (α) between a slanted surface (9) of the edge (3) and a cross-section surface (10) is dependent on the thickness of the jacket portion (6).

7. Stud according to Claim 2, particularly for welding to a relatively thick structure, preferably a metal sheet, characterized in that an angle (α) between a slanted surface (9) of the edge (3) and a cross-sectional surface (10) is up to around 45°.

8. Stud according to Claim 2, characterized in that the angle (a) between a slanted surface (9) of the edge (3) and a cross-sectional surface is between 5° and 15°.

9. Stud according to Claim 2, characterized in that the angle (a) between a slanted surface (9) of the edge (3) and a cross-sectional surface is between between 7° and 10°.

10. Stud according to Claim 2, characterized in that the angle (a) between a slanted surface (9) of the edge (3) and a cross-sectional surface is approximately 9°.

11. Stud according to Claim 2, characterized in that said stud has a threaded bore (11) formed substantially coaxially to the circumferential edge (3), said stud (1) having a cover (17) protruding at least partially from the edge (3) into the threaded bore (11).

12. Stud according to Claim 9 characterized in that the cover (17) is made of synthetic material.

13. Stud according to Claim 2 characterized in that said stud has a shape allowing said stud (1) to be positioned in one pre-determined position only in a tool.

14. Stud according to Claim 11, characterized in that said stud (1) is asymmetrically shaped.

15. Stud according to Claim 12, characterized in that the outer contour of said stud (1) is asymmetrical.

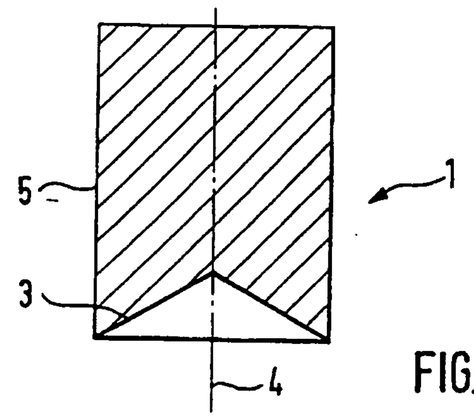

FIG. 1

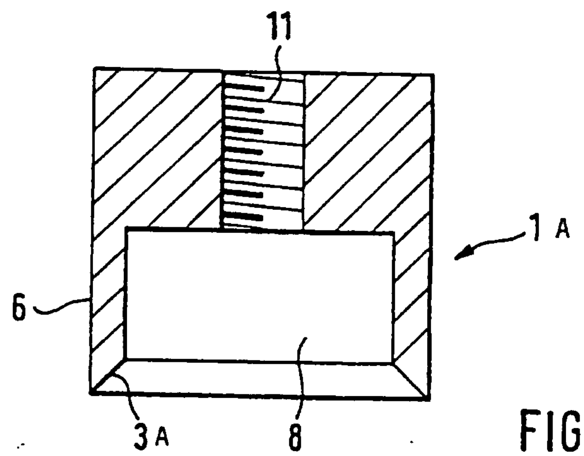

FIG. 2

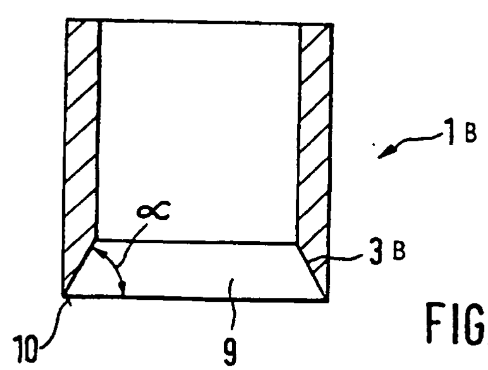

FIG. 3

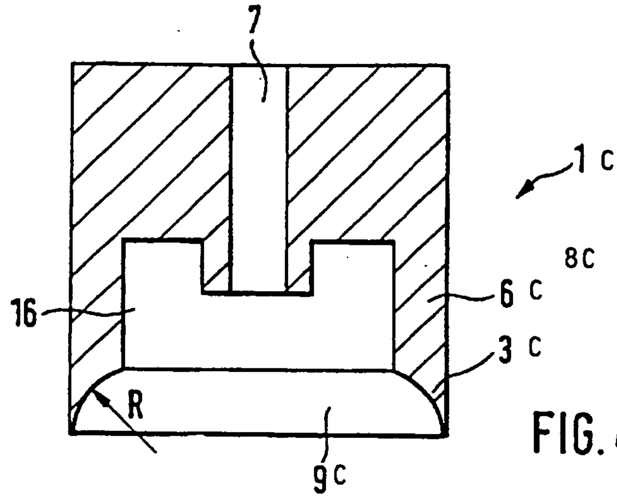

FIG. 4

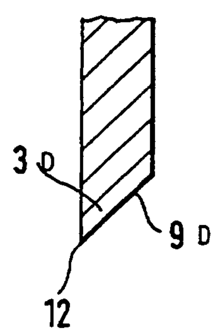

FIG.5

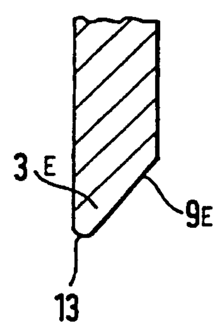

FIG.6

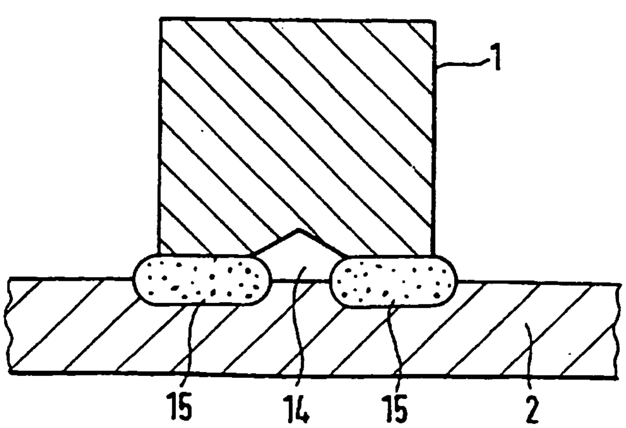

FIG.7

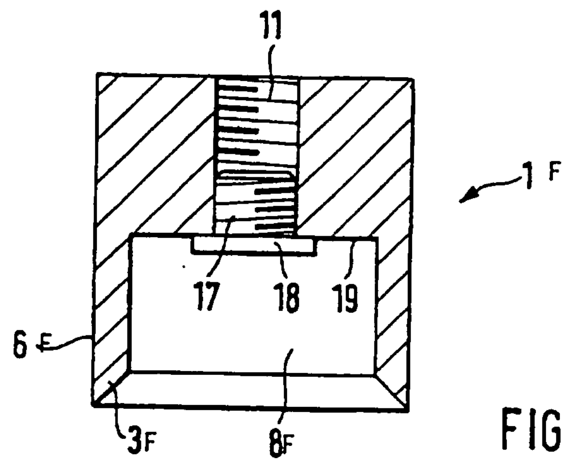

FIG.8

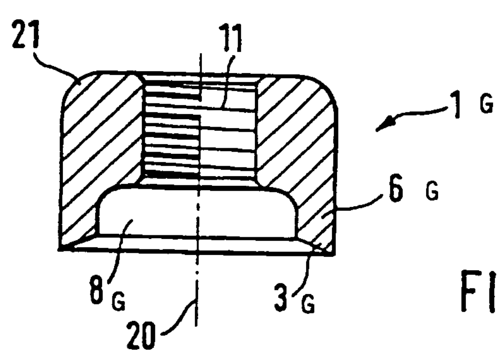

FIG.9

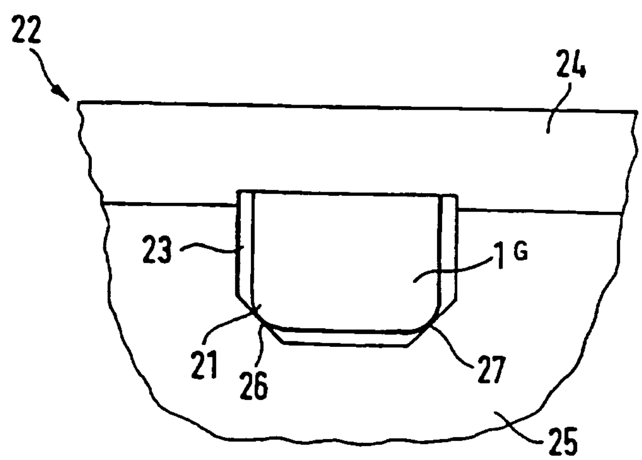

FIG.10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/05365

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B23K 9/20
US CL :219/99, 98; 411/171
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 219/99, 98; 411/171

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,363,084 A (BUSING) 09 January 1968, see the entire document	1-15
A	US 3,671,710 A (COOMBS) 20 June 1972, see the entire document.	1-15
Y	US 5,349,152 A (RENNER) 20 September 1994, see figure 3.	11,14
X ---- Y	GB 2065011 A (BREGENZER et al.) 24 June 1981, see the entire document.	1-10, 12, 13, 15 ---- 11, 14

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